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LOCOMOTIVE CONSTRUCTION.

The Construction of the Modern Locomotive. By George Hughes. Pp. 260. (London: E. and F. N. Spon, 1894.)

OF all the many branches of engineering, that of locomotive engineering has been generally overlooked by the writers of text-books, and until quite recently the only works on this important subject were the classical works of Z. Colburn and D. K. Clerk, "Locomotive Engineering and the Mechanism of Railways," and "Railway Machinery." These works are more than twenty years old, and do not now represent modern practice, although the rules and formulæ given are largely made use of to this day, besides which the experimental data obtained by D. K. Clerk on the old Edinburgh and Glasgow Railway, some time before the year 1855, may still be regarded as of great value.

Locomotive engineers in this country owe more to the late Mr. William Stroudley than they care to admit. To Mr. Stroudley is due the thoughtful and careful designing of every part of the locomotive, from the valve motion to the damper on the ash-pan, and, thanks to his example, locomotive design has become as near a science as it is possible to be, always bearing in mind that abstract calculations are nearly useless for this purpose. A very important point in the design of a locomotive is that of facility of repairs in the running-shed. It is possible to point to more than one type of British engine where the draughtsman appears to have had entirely his own way in the design, and consequently an ordinary repair, such as changing a spring, entails the partial stripping of the engine in order to lift it high enough to effect this; whereas it should be possible to do it with a couple of jacks, just to ease the weight off the spring, take the pins out, and then replace the spring. Another similar case may be quoted. Some heavy main line passenger tank engines have recently been constructed; and should a copper stay leak badly on the side of the fire-box, the side tanks cannot be removed to get at the leak without cutting out rivets and removing the angle-iron supporting the side platform; whereas had the draughtsman been an engineer, he would have foreseen such an emergency, and provided for it. These examples are sufficient to show that when designing an engine, the position of every pin and bolt should be carefully considered, so that their removal, if necessary, will be an easy matter in the running-shed.

The volume before us, unfortunately, does not deal with design, but treats only with the manufacture of a locomotive in the works of the Lancashire and Yorkshire Railway Company at Horwich. As these works are comparatively new, it is only fair to expect to find the practice thoroughly up to date, and as the author is an assistant in the chief mechanical engineers' department, the information given may be considered to be authentic. The title chosen for the book is a little misleading, because only one type of engine is discussed; moreover, this engine is fitted with the Joy valve gear, a type of motion certainly not generally adopted by locomotive engineers.

The work is divided into six sections, and these are again subdivided when necessary. Each section describes the actual progress of the work done in that section. Taken as a whole, this book is unique; it is the only one we know of that appeals to the locomotime engineer in the language and phraseology of the works, and without the cant usually found in text-books of to-day dealing with mechanical subjects. The book being of a thoroughly practical nature, it may be as well to follow its contents in order.

Section i. deals with the boiler, the materials used in its construction, and the methods of manufacure. Steel is the material used for the shell in most cases. The author observes that if a plate is buckled, this buckling is got out of the plate by planishing, or by a multiple roller straightening machine. The former method cannot be recommended for boiler-plates, but for tank side, cab, or splasher-plates it is the common practice. The question of locomotive boiler drilling is thoroughly well gone into, but the methods described are not those of most recent practice, which may be concisely stated to be—the edges of all plates must be machined, rivet and other holes to be bored after rolling the plates to shape, and drilling all holes out of the solid. Many complicated multiple drilling machines have been constructed to meet these requirements, but it is questionable whether such complicated tools are necessary, especially when the self-pitching attachment is used, because the holes in each seam must be set out in order to find the position of the holes for the "holding together" bolts, which are usually placed 12 to 14 inches pitch, and which are usually drilled through a template in bunches before the plates are rolled. Further on the author describes a plate-bending machine capable of rolling a plate to the very edge. As such a machine is certainly very badly wanted it may be here questioned whether the one described is really capable of doing this. The old method of setting the last 4 or 5 inches with a "former" has long been condemned, but with vertical rolls the ends of the plates may be rolled to the true radius by means of a curved packing piece which holds the plate up to the movable roll, resting against the smaller live rolls behind.

We are told that the inside and outside butt strips are sheared to size, and not machined on edge; unless they are afterwards annealed, this practice cannot be commended. One cannot help being astonished at the free use of cast-steel in the boilers. This is very much up to date; but what gain there can be in using a cast-steel tee-bar in place of a rolled one for the longitudinal and sling stay attachments, cannot be seen. The crown of the fire-box is stayed with cast-steel girder-stays or roof-bars, and ferrules are used to preserve the proper distances. Surely these ferrules might be replaced by bosses cast on the stay-bar, into which the bolts would be screwed, thus strengthening the bar, and being less complicated. The foundation rings are also of cast-steel; these castings evidently require much setting and "paening." Surely they are machined inside and out, as required by good practice?

The paragraphs dealing with flanging plates and the tools used, leave nothing to be desired; they are concise and to the point. Reasons might have been given for the adoption of the "Webb" fire-hole; it seems to

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entail very severe treatment of the plates for no obvious purpose. There are many ways of placing the copper stays in position, and the author evidently cuts off the ends after screwing them home. Here he is behind the times: "modern practice" requires them to be cut to length in the lathe, afterwards being screwed home by a sort of stud-driver. This does away with any chance of injuring the threads by cutting them in position by eccentric portable shears, or the more barbaric hammer and chisel.

The quadruple tapping machine (illustrated) no doubt does its work very well, but it must be moved from boiler to boiler, and this entails much labour and loss of time; a far simpler tool is generally used, namely, a light radial jib carrying a movable carriage, over which the ropes run to the tool-holders, all the compensating gear being on the wall. Taken as a whole, Section i. is extremely well written, and covers a large field of detail; it concludes with the testing of the completed boiler. The hydraulic test of 200 pounds per square inch is much below the usual test-pressure in water, viz. one and a half times the working pressure, for new boilers.

Section ii., occupying eighty-seven pages, is divided into three parts. The first part deals with the iron foundry, the second on the use of steel castings, and the third describes the brass foundry. It is evident, after careful perusual, that much attention has been given to this particular branch of the works, especially the careful manner in which the mixings of the different metals is carried out, and the valuable illustrative tests showing the necessity for annealing steel castings. As an example of foundry practice, we find a full description of the moulding of a pair of twin cylinders, probably the most difficult and important piece of work occurring in a railway foundry; a few other examples are also given. In part two of this section the author wisely suggests that engineers should formulate a standard specification for the grade of material for steel castings for locomotive work, and recognise a standard size for both tensile and bending test bars. With this we cordially agree; specified tests vary far too much, and in some cases tend to make the specifying engineer a laughing-stock for contractors.

Section iii., dealing with forgings, is divided into two parts. The manufacture of tyres, axles, coupling rods, and smaller details, is well described, the usual tests being given. The method of work is illustrative of modern practice, particularly the stamping of detail work under the drop hammer. Engine tyres for India usually are required to have a minimum tenacity of from 42 to 44 tons, and with a sectional area of test piece of ½ square inch. The extension, measured over a length of 3 inches, must not be less than 20 per cent. The second part of this section deals with the manufacture of springs, among other things. Page 164 illustrates the means taken to weld a lever on to a shaft; figures C and F may make a "job," but it is preferable to fit the lever end half through the shaft before welding—that is, for a brake or a reversing shaft; for a damper shaft, a dab weld may be good enough.

In Section iv. we find a description of general copper-smith's work; and in passing we may observe that the hemispherical tops for steam dome casings are in some works made from mild steel plates in dies under the hydraulic press, as well as the upper parts of safety-valve casings and corner mouldings for fire-boxes. This reduces the cost of these items considerably.

The machine department of a locomotive works is always interesting. The machinery is in many cases of a special nature; and in railway works, where duplication is said to exist, the machines may be still more of a special type, because only one class of locomotive is made. The Horwich Works appear to be largely fitted with milling machinery, to judge by the amount of care the author takes in his descriptions. Whether milling in its competition with planing, slotting and shaping machines, will ultimately prove the cheaper process, remains to be seen. On page 204 we find the statement that all frame-plates are put on the levelling table and straightened (levelled?) by the aid of two hydraulic jacks; further on we read that the frame template has been given up, owing to its liability to become distorted, and that a man can draw in a frame in two hours: again, it is stated that a batch of eight frames is slotted, firstly by roughing out, and secondly by a finishing cut. Surely this cannot be called modern practice? To thoroughly and truly level a frame-plate it is necessary to heat it to a cherry-red heat, and level it on a plain surface; for this reason it is usual to punch the frame-plate roughly to shape before being levelled. This punching to shape allows the frame-slotting machine to commence at once roughing out the bunch of plates. Moreover, the plate is more or less annealed by the furnacing.

The frame template generally used is made in three pieces dovetailed together, and the angle-iron bracing is conspicuous by its absence: very little trouble is caused by such a template. Surely the author has made some mistake in stating that a man can "mark out one frame, which is a two hours' job." To mark out a frame from a drawing, without a template for slotting and drilling, will take one man two days or more. Moreover, the frame-plates are not said to be planed on one side. If this is the case, much time is lost in erection and fitting the horn-blocks, assuming of course this fitting is properly done. Such a frame-plate can be planed in from three to four hours.

Case-hardened wrought-iron axle-boxes are said to be things of the past! The Midland Railway Company use nothing else, and many new engines for other railways are being fitted with them; in fact, such boxes working in chilled cast-iron or cast-steel guides are hard to beat.

The last section of this interesting book deals with the final erection of the engine, and we are glad to see that Horwich does not go in for throwing an engine together in ten hours or more, to be afterwards re-erected when the "wonder" has ceased to be talked about.

It appears that the practice of fitting the horn-blocks to the frames when in a vertical position is followed. This cannot be commended; it is far easier for the men to do it before they reach the erecting-shop, when laying on trestles; the holes can then be opened out, and the bolts or cold rivets driven in comfortably. Pianoforte wire has long been abandoned for squaring over cylinder centre-lines by contractors, for the reason that it can be bent between the fingers, and thrown one way or another by the men. The three-inch tube for setting the slide-bars cannot be trusted for accurate work, owing mainly to the end drooping by its own weight, and slackness in the glands and temporary front cylinder cover. Squaring over the frames is now done by a long square, one arm being placed through the driving horns, and held against them. The distance is then measured from the leading and trailing horns to the other arm of the square when held in the four positions. If the frames are square, these measurements should agree, if the horns are similar throughout. A woven silk cord is best for lining up the frames and cylinders.

The volume concludes with a lengthy description of the Joy valve gear, a gear not generally used in locomotive work. It is a pity the author does not treat the so-called Stephenson link motion in a similar exhaustive manner. In conclusion, we must congratulate the author on having written the first readable and accurate book on the construction of the locomotive engine. He has treated his subject in a masterly way; he describes, as a rule, the most recent practice in a thoroughly professional manner. The work is well and copiously illustrated, and will be of great use to those who take an interest, either professionally or in an amateur way, in the construction of the locomotive.

N. J. LOCKYER.

INDO-MALAYAN SPIDERS.

Malaysian Spiders. By Thos. and M. E. Workman. Parts 1, 2, and 3. (Belfast: Published by the Authors, 1894.)

THE material upon which this work is based was obtained by the authors during a recent visit to the East Indies; and since the entire collection has been submitted for examination and description to Dr. Thorell, who has made a special study of the Arachnida of this quarter of the globe, it may be taken for granted that the species have been as satisfactorily identified as is possible. Most of them, whether old or new, have been already described in detail by this specialist. But his systematic zoological work, although in its way of unrivalled excellence, is open to two objections. We have, in fact, heard it alleged, firstly, that the span of human life is too short, and the number of existing spiders too great, to admit of deserving attention being paid to his exhaustive descriptions; and, secondly, that a deal of vexatious trouble and valuable time might be saved by the addition of a few figures to the overwhelming amount of text. It is evident that Mr. and Mrs. Workman have realised the full force of these two objections; for this book of theirs may be briefly described as a supplement designed to make good the defects in Dr. Thorell's report upon their collection.

The work is being issued at intervals in shilling parts, of which three, comprising in all twenty-nine plates, have up to the present time appeared. Every species is illustrated by a hand-coloured figure, together with outline sketches of structural details; and accompanying each set of figures is an explanatory page of text, giving the name and synonymy, the affinities and distribution of the species, and some measurements of the type-specimen. Moreover, in some instances interesting items of news respecting habits, &c., are added; and in the case of the orb-weavers, a figure of the web characteristic of the species is engraved on a separate plate. It is this part of the work, we feel sure, that will prove of the greatest interest to the student of spider-life. Even the pure systematist may learn from it valuable facts bearing upon his aspect of the subject. For the figures and descriptions of the webs afford indisputable evidence that remotely allied genera may construct snares of substantially the same kind, as may be seen by a comparison of the nests of *Callinethis*, *Gea*, *Argyroëpeira*, *Epeira*, and *Gastracantha*, represented in parts 1 and 3; and that within the limits of the same genus, species may be found that spin webs differing widely in important points of structure, as a glance at the figures of the webs of *Epeira calyptrata*, *unicolor*, and *beccarii*, in parts 1 and 3, will show. Clearly the importance of these facts must be steadily kept in view by those who base their classification of spiders on the structure of the webs.

The discovery of the snare of *Uloborus quadri-tuberculatus* has given rise to a curious problem. This web is always spun on the pine-apple, and is of a peculiar basket-shape, the peculiarity consisting in the remarkable adjustment that is exhibited between the structure of the web and that of the plant. But the pine-apple is a native of South America, and has only of late years been introduced into Singapore; so that if the spider is truly a native of the latter place, it has evidently rapidly modified its spinning instincts in response to the slight change in its environment brought about by the introduction of the pine-apple. Before such a conclusion, however, can be looked upon as an established fact, evidence must be produced that the spider and the plant were not concomitantly brought from the Neotropical to the Oriental region.

Another very interesting fact is noticed in connection with *Argyroëpeira striata*. We are told that this spider, which is normally of a bright golden tint, "has the power of darkening down its brilliant colouring when frightened." (part 3, p. 19.) The importance of this observation is greatly enhanced by the independent discovery made by Mr. H. H. J. Bell, and published in NATURE (vol. xlvii. p. 558), to the effect that a West African species of *Argiope* possesses the same faculty of rapidly varying its colour under the stimulus of changing surroundings.

From what has now been said, it may be judged that the value of this book, as an addition to the literature of spiders, is both great and unquestionable. But it is impossible to shut one's eyes to the fact that its general excellence is slightly marred by a few blemishes, which, at the risk of appearing ungrateful, we think it our duty to point out; not, be it understood, with the object of fault-finding, but in the hope that none of them may be copied by other authors, and that some, at least, may not reappear in succeeding parts of the work.

In the first place, respecting the method of publication, it is a pity that both preface and introduction have been altogether omitted, and that species belonging to such widely different families as *Oxyopidæ*, *Attidæ*, *Thomisidæ*, and *Epeiridæ*, should be indiscriminately mixed, as they have been in part 1. With regard to the preface, we hope that the authors will see the application of the maxim, "Better late than never"; and although the adage, "What is done cannot be undone,"